

MAGNETIC MODELLING AND INTERPRETATION

Objective - Use the interactive modelling package "MAGIX-plus" to become familiar with the characteristics of magnetic anomalies for some simple models. Then, use MAGIX-plus to interpret some aeromagnetic anomalies observed in Northern Ontario using an iterative modelling process.

1. Magnetic Modelling Study

Generally, the magnetic field response of a body is significantly more complicated than its gravity response because of the directionality of the body's magnetization and the directionality of the observed quantity. For example, the profile across an even-symmetric body will only be even symmetric at the geomagnetic pole or equator. Use the modelling program MAGIX-plus to familiarize yourself with the character of magnetic response; first by investigating the total field intensity response of some given 2D bodies for different values of the dip of the Earth's magnetic field (i.e., for different geomagnetic latitude of the survey area); then by examining the response of a thin dyke-like body as a function of dip and depth extent. Describe how variation of the model parameters affects the response. Also, for some case, check how sensitive the response is to change in strike length and depth of the body. Since this is an initial exercise, assume that all magnetizations are induced only (no remanence) and that all measurements are of total magnetic field, and that the strike of all bodies is geomagnetic east – west. (What is the effect of orienting a body of long strike length geomagnetic north-south?)

Specification of the quantity measured by the survey, the orientation of survey lines with respect to the bodies and the strength of the earth's field and its declination and inclination are set under the command EDIT Data Parameters.

Use the file P2M.MGX, which draws 3 bodies with different cross-sections in one profile, to examine the effect of field orientation. Draw your own cross-section for the thin dyke modelling. You do not need to vary susceptibility during your forward model studies, because this just alters anomaly intensity proportionally. However, choose a realistic susceptibility (1 volume % of magnetite generally corresponds to about .04 SIU of susceptibility), and remember that 20 nT is a very small anomaly that can barely be recognized in older airborne surveys like the one for which example data are given. Be aware that MAGIX may not plot the visual cross section of the model with a 1:1 vertical to horizontal scale.

2. Magnetic Interpretation Study

You are supplied with copies of the aeromagnetic map of a small area in northeastern Ontario. The displayed anomalies are due to geological formation containing magnetite that are part of the 2.7 Ga Archean "Superior Province", the igneous – metamorphic complex that underlies most of northern Ontario. Some 10's of kilometers to the north and east of this area, the situation is more complicated and Proterozoic (0.6 – 2.5 Ga) formations are present together with the Archean rocks. Like all of Ontario, the bedrock of this area is widely covered with a few meters or 10's of meters of Quaternary glacial debris. However, in this region near James Bay, up to a kilometer of flat-lying Phanerozoic sediments (< 0.6 Ga) that do not contain appreciable magnetite overlie the Precambrian formations. One of your tasks is to estimate the total thickness of Quaternary and Phanerozoic sediments. (This can be done by utilizing the high probability that many of the susceptible bodies are (deformed) sheet-like bodies. Thus, a steeply dipping anomalous feature in the Precambrian complex is likely to have its top edge cut by the Precambrian–Phanerozoic boundary). Another objective is to estimate the form and dip of the anomalous formations.

The aeromagnetic survey was flown in the late 1960's with north-south flight lines separated about a half mile (800 m), and with a terrain clearance of about 1000 ft (330 m). The original plotting scale for the contoured aeromagnetic data was 1 inch = 1 mile (~ 1:63 k). An interpretation of Precambrian geology of the larger region surrounding and north of this area is discussed in a report by H. H. Bostock (GSC Report 70-42, Aeromagnetic Interpretation of the Aquatuk River Region). A display board of 1:250k scale aeromagnetic maps and an extract from the report is posted in the laboratory.

Draw up at least two profiles across at least two of the long strike length anomalies and enter them into MAGIX as data files. First, apply some of the simple interpretation rules based on anomaly half width or gradient to get some idea of body position. (See Lab Notes.) Then, try to match the observed data with a cross section that you draw in MAGIX. As a first step, you will need to subtract the regional background from the anomaly you intend to model. MAGIX provides a way to specify this under the command EDIT Regional. Make sure you do this consistently for all cases.

If you enter a long data profile into MAGIX, you will probably see other weak local anomalies in addition to the main one you want to model. Do *not* try to draw a body that will fit all these features at the same time as you try to fit the main anomaly. Start the modelling with a very simple shape like a thin, vertically dipping dyke. Keep the thickness of the dyke constant until you have adjusted the height and location of its top and its bottom to get a reasonable fit. Concentrate on fitting the geometrical shape of the anomaly. Usually, there are few *a priori* constraints on the susceptibility of the body, so you can freely vary it to make the anomaly amplitudes fit. Remember, if the body thickness is small relative to depth to top, it will affect only anomaly amplitude.

Familiarize yourself with facilities in Magix to control the data and model plot-scaling (EDIT Data Axes, EDIT Model axes, RESET Axes) and to control modelling (INTERPRET options). You should begin by manually editing your body, but eventually begin to use the automatic INVERT facility. But when using auto INVERT, allow only a minimum of parameters (in addition to susceptibility) to vary in any single step of inversion. (Toggle Body Parameters, Toggle Vertex Parameters.)

Once a model has been found that gives a reasonable, try to estimate the robustness of that interpretation by finding out how far you can change various parameters of the model without introducing serious misfit. In your report, describe what procedure and assumptions you eventually used to arrive at the fitting models.

3. Alternatives

There are many other data examples in the geophysics laboratory in addition to the one described in 2. You may model some of these examples instead, if you wish. For example, you may wish to select features from the data set provided in P1.